Total Nitrate Variation at Mauna Loa

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INTRODUCTION

Much of the NO and NO_2 emitted into the atmosphere is converted to nitric acid vapor or aerosol nitrate before being removed by dry or wet deposition. This conversion to nitrate is largely complete within a few days of the odd-nitrogen's emission; therefore in remote areas such as at the Mauna Loa Observatory, the total nitrate concentration (vapor plus aerosol) represents a fair estimate of the total odd-nitrogen concentration [*Atlas et al.*, 1992].

With support from NSF, we have measured nitrate concentrations at MLO for several years to help identify the important sources of odd-nitrogen compounds in remote parts of the globe. We now measure total nitrate every night from the walkup tower in collaboration with the MLO staff.

MATERIAL AND METHODS

A Teflon/nylon filter pack method is used for collecting atmospheric nitrate. Since August 1988, one filter has been exposed each night, from 2000 LST to 0800 LST. Filters are returned to the University of Hawaii for extraction and analysis by ion chromatography.

The data from August 1991 to July 1992 was, unfortunately, treated somewhat differently from the remainder. These samples were all analyzed as a batch during a brief period between the return of our analytical laboratory from a field deployment in the Azores and its shipment to its new home at the University of Hawaii. Once it became apparent that this data looked very different from previous years, it was no longer possible to replicate the analytical conditions or the standards to resolve questions of its validity.

RESULTS AND DISCUSSION

Lee et al., 1993 published a description of gradient measurements of nitric acid and aerosol nitrate at MLO. This work showed that surface-active species like nitric acid often have large gradients near the surface at MLO, raising the potential for underestimating free tropospheric concentrations due to depletion of material upstream of samplers. The deposition velocity of nitric acid to the lava surface varied from 0.3 to 4 cm s^{-1}.

During our intermittent MLO sampling prior to September of 1988, we observed a sharp maximum in nitric acid and aerosol nitrate concentrations in the summer. The search for an explanation for this maximum continues to stimulate our science. The daily total nitrate values for 1993 are plotted in Figure 1. The lowest sustained concentrations are still evident in the winter, with a mix of high-concentration events and cleaner periods in the spring and late summer.

Figure 2 shows monthly averages of 2000 LST to 0800 LST total nitrate concentrations from September of 1988 to May of 1994. The questionable data from 1991 and 1992 (represented by smaller dots) is included for completeness, although we have serious questions about its validity. The 1993 data represent the lowest (defendable) concentrations we have observed during our sampling at MLO. They may represent a minimum, however, since early 1994 concentrations have returned to levels not seen since 1990.

The concentration of total nitrate at MLO is to a large extent controlled by precipitation scavenging of soluble material during transport from the continents [*Lee et al.*, 1994] so this interannual variability may be an indicator of changes in large-scale precipitation patterns. The

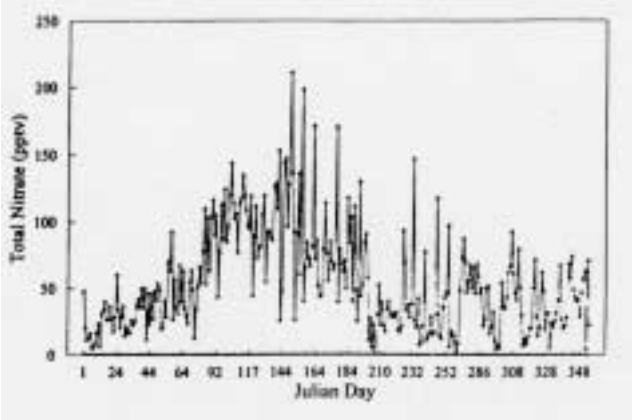

Fig. 1. Nightly concentrations of total nitrate in 1993.

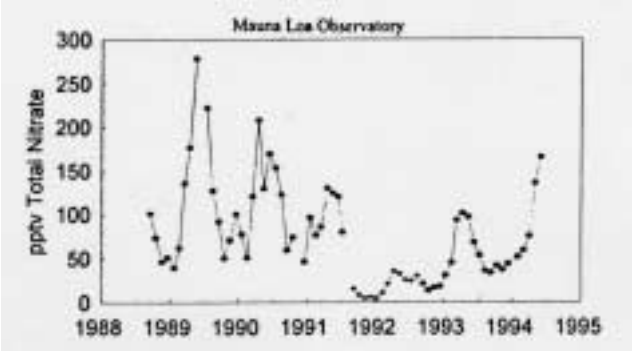

Fig. 2. Monthly average total (aerosol plus vapor) nitrate versus time.

apparently-monotonic decrease in summertime total nitrate from 1988 through 1991 suggests that a cyclic process, such as the southern oscillation, may be reflected in this record. It is certainly reasonable that the transport of continental materials like mineral aerosol and fixed nitrogen (which can be limiting nutrients in certain parts of the Pacific) should be sensitive to changes in large-scale atmospheric circulation patterns. Clearly we need to identify the climatological differences that cause this dramatic change in the annual cycle of nitrate from one year to the next since they may have impacts on phenomena as diverse as marine biological productivity and the earth's radiation budget.

ONGOING RESEARCH

We are continuing our inclusive nightly sampling from the tower with the help of the MLO staff. Although equipment failures and analytical problems have occasionally caused lapses in the data, a very interesting record is emerging. We intend to continue this total nitrate data record in the hopes of identifying those factors that control the form and the range of its annual cycle.

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